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UNITED STATES
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J. A. KRUG, SECRETARY

BUREAU OF MINES
JAMES BOYD, DIRECTOR

INFORMATION CIRCULAR

METHODS AND COSTS OF SINKING A 2-1/2-COMPARTMENT SHAFT AT THE HOPE MINE, CLARK FORK, IDAHO

BY

ROBERT J. HUNDHAUSEN

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By Robert J. Hundhausen[2]

FOREWORD

In 1946 the Mining Branch of the Bureau of Mines, through its field offices, and engineers renewed the series of information circulars on various phases of mining and milling methods and costs. During the war, emphasis was placed on other investigative problems, with the result that this series was largely discontinued.

The primary purpose of these Information Circulars is to disseminate technologic data pertinent to mining and milling operations for the benefit of the entire mineral industry.

LOWELL B. MOON,
Chief, Mining Branch.

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[1] The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7426."

[2] Mining engineer, Albany Division, Mining Branch, Bureau of Mines.

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INTRODUCTION

This paper describes the methods and costs of sinking a $2\frac{1}{2}$-compartment shaft at the Hope mine, Clark Fork, Idaho. The Hope mine is owned by the Hope Silver-Lead Mines, Inc. Albert E. Nash, of Clark Fork, is president and manager.

ACKNOWLEDGMENTS

The writer is indebted to Albert E. Nash, Manager, and Mrs. Mary Nash, secretary-treasurer, for their cooperation in assembling these data and also for their kind permission to publish them. Elmer T. Shields, shaft foreman, furnished detailed information on all phases of the work under his supervision.

PURPOSE OF SHAFT

The principal mines, vein structures, and faults found in the Clark Fork district are described in a recent report by S. H. Lorain.[3]

Lorain's report also describes exploratory diamond-drilling work conceived and performed by the Bureau in a successful effort to prove the persistence of a strong mineralized fault (the Pearl vein) beneath the 400 feet of alluvium that covers the bottom of Lightning Creek Valley. The shaft described in this paper is being sunk to explore the Pearl vein for ore shoots beneath the alluvium cover. The shaft will also be used to explore the Hope mine at depth. The Hope mine, until recently, was producing lead, silver, and zinc from a small but persistent bedding plane vein that strikes N. 40° E. and dips 15° to the southeast. Long, inclined winzes on the dip of the vein gave access to the deeper mine workings, but it is now planned to explore and mine the downward extension of the vein from the new shaft.

GEOLOGICAL FORMATIONS

The Clark Fork district is underlain by the Wallace formation of the Belt series (pre-Cambrian). The Wallace formation is composed of thin-bedded, calcareous shales, quartzites, and argillites. These beds, in the vicinity of the mine, strike N. 40° E. and dip 15° southeast.

Excepting a few feet of overburden at the surface, the shaft is entirely in the Wallace formation. The rock is of medium hardness throughout.

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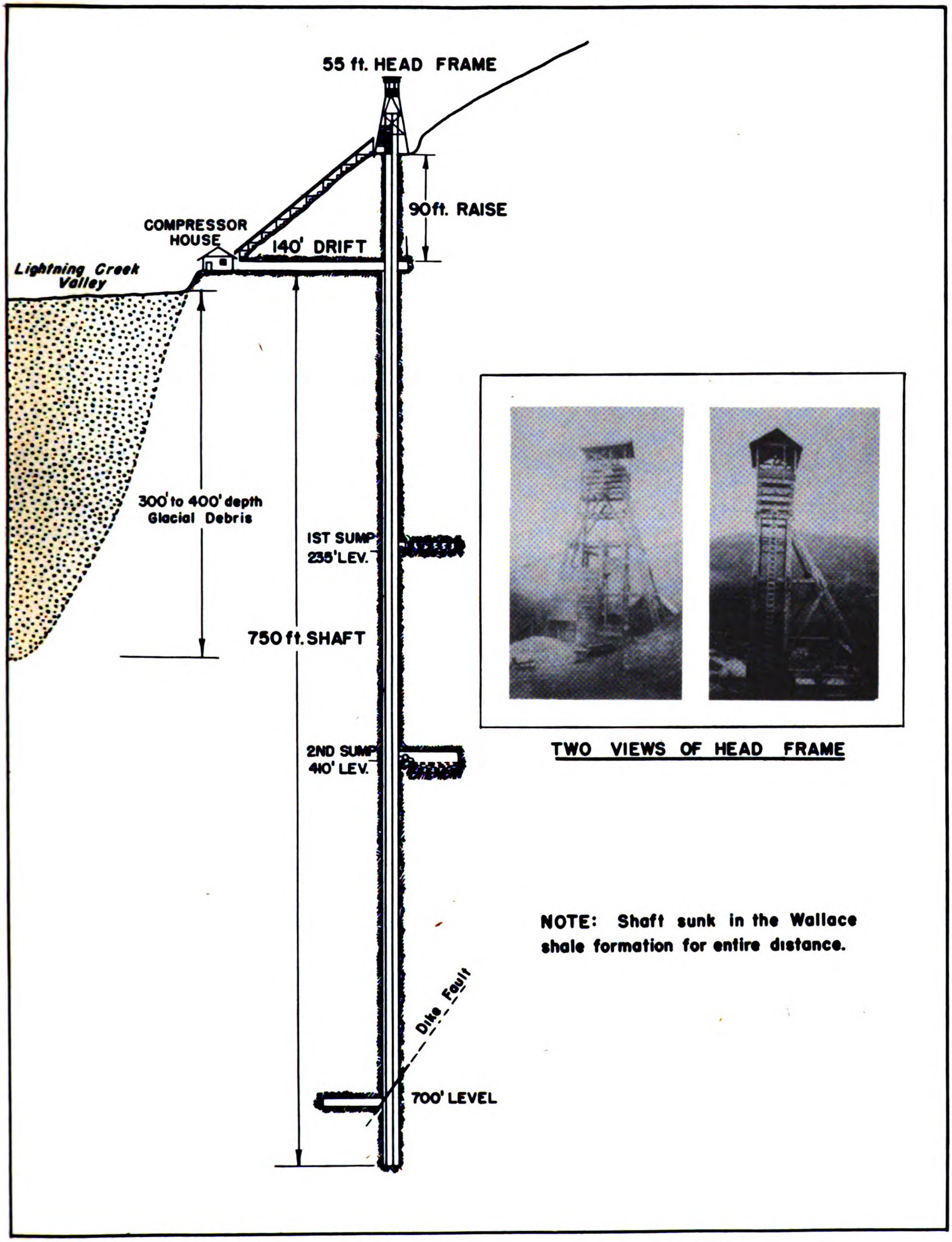
[3] Lorain, S. H., Clark Fork Lead-Zinc District, Bonner County, Idaho: Bureau of Mines Rept. of Investigations 3992, 1946, 10 pp.



TWO VIEWS OF HEAD FRAME

NOTE: Shaft sunk in the Wallace shale formation for entire distance.

Figure I. - Hope shaft and head frame.

According to E. T. Shields, foreman, three small vein structures were cut in the shaft at depths of 20 feet, 280 feet, and 420 feet. The first and second veins consisted of altered, broken zones, about 3 feet in width. The third vein was 4 feet wide and contained a prominent 4-inch seam of "high grade" lead-silver ore. All three veins dip parallel to the bedding planes.

The shaft was so located as to intersect a fault known as the "Dike" fault at a depth of approximately 700 feet. The fault was actually encountered in the shaft at a depth of 680 feet; it passed out of the southwest wall at a depth of 700 feet. The "Dike" fault is a strong premineral or intermineral fault which passes through the Hope mine workings southeast of the shaft and intersects the Pearl vein northwest of the shaft. It strikes N. 40° W. and dips 60° southwest.

The development plan now in progress is to drift northwest along the hanging wall of the Dike fault on the 700 drift level off the shaft. This drift will crosscut the Pearl vein approximately 1,100 feet from the shaft.

The shaft-sinking operations were handicapped by a heavy flow of meteoric water. The only individually strong watercourses encountered were the three small vein structures previously mentioned. Most of the water seeped in along the innumerable joints, cracks, and bedding planes of the porous shale country rock. Facile movement of the subsurface water through the shale is demonstrated by the fact that the water level in the Hope mine was lowered uniformly as the shaft was deepened, even though the mine workings and shaft are separated by almost a thousand feet of the shale formation. Pumping operations are discussed later in this report.

PREPARATION FOR SHAFT SINKING

The shaft was located at a point midway between the two target areas; that is, the Hope-mine deep-level exploration work to the southeast and the Pearl-vein structure to the northwest. Knowledge of the character of the shale formation was gained by experience during work in the Hope mine and by Bureau of Mines diamond drilling.

The Pearl-vein target area lies beneath valley alluvium known to be over 400 feet thick. A shaft site was, therefore, selected where bedrock was exposed on the hillside adjacent to the valley fill (fig. 1). To further determine the nature of the bedrock in this locality, a 6- b6 8-foot adit was driven into the hillside just above the valley fill. About 130 feet from the portal a two-compartment raise was driven to the surface, a distance of 90 feet. Each compartment was 5 by 5 feet in the clear. When the raise broke through, the surface was cleared and leveled for the erection of the head frame. Surface leveling was accomplished with the aid of an air tugger hoist and scraper. A five-man crew completed the clearing and leveling in 3 weeks.

The wooden head frame of the Hope shaft is 55 feet high and has four front posts. The timber is all fir, 10 by 10 inches in cross section, with the exception of the two 12- by 12-inch girders supporting the sheavewheel.

The timbers are braced with steel tie rods 5/8 inch to $1\frac{1}{2}$ inches in diameter. With few modifications, the head-frame design is similar to, and patterned after, a design shown in figure 13 in Bureau of Mines Information Circular 6943.[4] Figure 1 shows two views of the Hope-shaft head frame. A 20-ton ore bin is built into the head frame.

The head frame is anchored to concrete footings. Three footings are on the uphill side, one footing for each post. These three footings are doweled into bedrock by means of short pieces of drill steel. The uphill footings are 3 feet square on the bottom, 3 feet deep, and taper to 16-inch width at the top. Only two footings are on the downhill side, one for the two front posts and one for the rear post. These footings are 6 feet deep on a 6- by 4-foot base, and taper to a 16-inch width at the top. They rest on a hard clay formation.

The concrete for the footings was mixed by hand. The sand came from a pit 4 miles away. A company-owned truck hauled the sand to the shaft side.

The preparation of the shaft site, with the erection of the head frame and the installation of the hoist, required 80 days time for a five-man crew. Of this time, 21 days were spent in clearing and excavating footings. Actual erection of the head frame took 20 days.

The shaft rock is dumped into a 20-ton bin built into the head frame. The rock is removed from the bin through a wood chute loading into a 16-cubic-foot mine car; it is then hand-trammed 100 feet to the dump.

The sinking bucket is dumped in the usual way by hoisting it just above a vertical, bottom-hinged door on one side of the hoisting compartment. A 6-foot air cylinder, controlled from the hoist room, pushes the door to an inclined position across the shaft. The bucket is then lowered onto the door and allowed to slide down until the heavy steel ball suspended from the free end of a short chain attached to the bottom of the bucket is engaged by a "wishbone" or V-shaped iron clamp fixed on the top of the door. Slacking off on the load causes the top of the bucket to assume a lower position on the incline than the bottom, thereby dumping the rock.

The air cylinder for the trap door was made at the mine from a 6-foot length of 3-inch pipe. The piston rod is a 1-inch round steel rod on which is bolted a simple washer head sealed with leather packing. It required 10 seconds to open the door, dump the bucket, and close the door again.

SURFACE PLANT

A timber framing shed and change room, a repair shop and compressor room, and a hoist house comprise the three surface buildings at the shaft site.

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[4] Staley, W. W., Design of Small Wooden Head Frames, Bureau of Mines Information Circular 6943, 1937, 37 pp.

Original from THE OHIO STATE UNIVERSITY

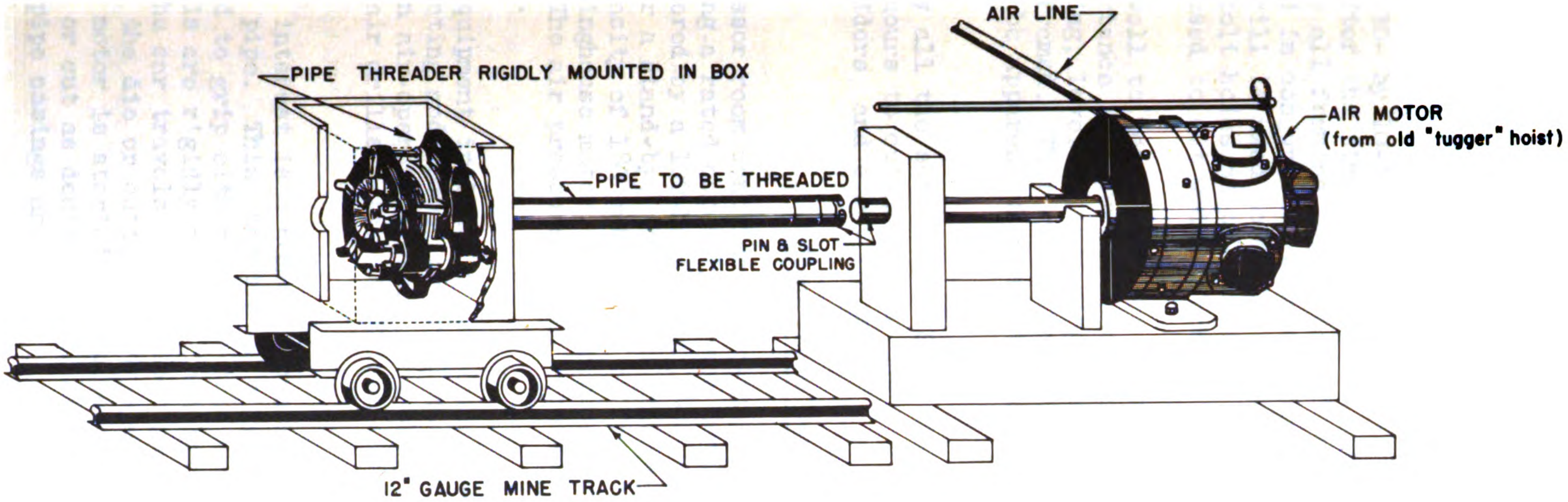

PIPE THREADER RIGIDLY MOUNTED IN BOX
AIR LINE
AIR MOTOR (from old "tugger" hoist)
PIPE TO BE THREADED
PIN & SLOT FLEXIBLE COUPLING
12" GAUGE MINE TRACK

Figure 2. - Home-made device for threading or cutting pipe or rods.

Timber Framing Shed

The timber-framing shed contains an air tugger hoist for pulling 16-foot lengths of 10- by 10-inch or 8- by 10-inch timber into a swinging cut-off saw. After the timber is sawed to desired lengths, it is sent to the framer where all framing and sawing of tenons and daps are done with a power saw used in conjunction with a caprenter's slick (chisel). A 3/4-inch electric drill is used to drill the holes for hanging rods and for countersinking bolt holes on the guides. A smaller specially designed cut-off saw is used to cut wedges from 2- by 4-inch lumber.

It may be well to point out here that accurate timber framing is of the utmost importance in securing good shaft alinement. Much time can be saved in timbering, leveling, squaring, and plumbing the shaft if the timbers are accurately framed. That good alinement has been accomplished in the Hope shaft will be apparent when shaft-plumbing methods are discussed later in this paper.

Practically all the sets for the Hope shaft were framed by one man. It required 8 man-hours to cut and frame one set of two wall plates, two end plates, two dividers, and eight posts.

Compressor Room

The compressor room contains a two-stage, water-cooled Worthington compressor having a rated capacity at sea level of 560 cubic feet of free air. It is powered by a 100-horsepower, 440-volt, General Electric induction motor. For a stand-by, there is a Chicago-Pneumatic compressor, having a sea-level capacity of 180 cubic feet of free air. It is powered by a 30-horsepower Westinghouse motor. The air receiver is 6 feet in diameter and 14 feet long. The air pressure in the receiver is maintained at 100 pounds per square inch.

The shop equipment includes a hand-made, well-designed, oil furnace employed for heating and tempering drill steel; also a Gardner-Denver bit sharpener and an air-operated forge. The shop is equipped for repairing motors, pumps, air drills, etc. An Edison cap-lamp charger set is in the shop.

Of special interest is a homemade contrivance for threading and cutting hanging rods or pipe. This consists of a geared-down air-tugger motor having a chuck attached to grip either a pipe or a hanging rod. The thread dies or pipe cutter tools are rigidly mounted in a box built on, and supported by, a small car. The car travels on a 12-inch gage track so that it may be moved to escort the die or cutter to any specified distance from the tugger. When the tugger motor is started, the pipe or rod in the chuck is rotated and either threaded or cut as desired (fig. 2). This contrivance is reported to cut 100 2-inch pipe casings an hour.

Hoist House

The hoist house is situated so that the hoist drum is 55 feet from the shaft, center to center. The hoist is powered by a 60-horsepower General Electric alternating-current motor and equipped with a friction clutch and wooden brake blocks. It has a 30- by 24-inch single drum holding 1,000 feet of 3/4-inch wire rope. The average rope speed is 240 feet per minute. This hoist was worn out during the latter stages of the sinking operations and will be replaced by a new, modern hoist as soon as the electrical equipment becomes available.

The new hoist, manufactured by the Coeur d'Alene Hardware Co., has a 6-ton gross load capacity, including cable, skip, and load. It has a 30- by 36-inch single cylindrical drum holding 3,600 feet of 1-inch wire rope. It is powered by a 200-horsepower direct-current General Electric synchronous motor equipped with dynamic braking. A Lilly hoist motor-control system provides push-button control at five different rope speeds. The maximum rope speed is 500 feet per minute. A motor-generator set will convert a 2,300-volt alternating current to 275-volt direct current for use by the new hoist motor. A direct-current hoist motor and control system has been found to be simpler, more efficient, and more responsive to duty than an alternating-current hoist motor-control system.

The power substation now transforms the incoming 13,000-volt current to a 440-volt circuit for use in the present hoist, compressor, and shaft motor pumps. In the shop a small transformer reduces 440 volts to 110 for the hoist signals, lighting, and electric blasting circuits. The new hoist will require some modifications in the power transforming system.

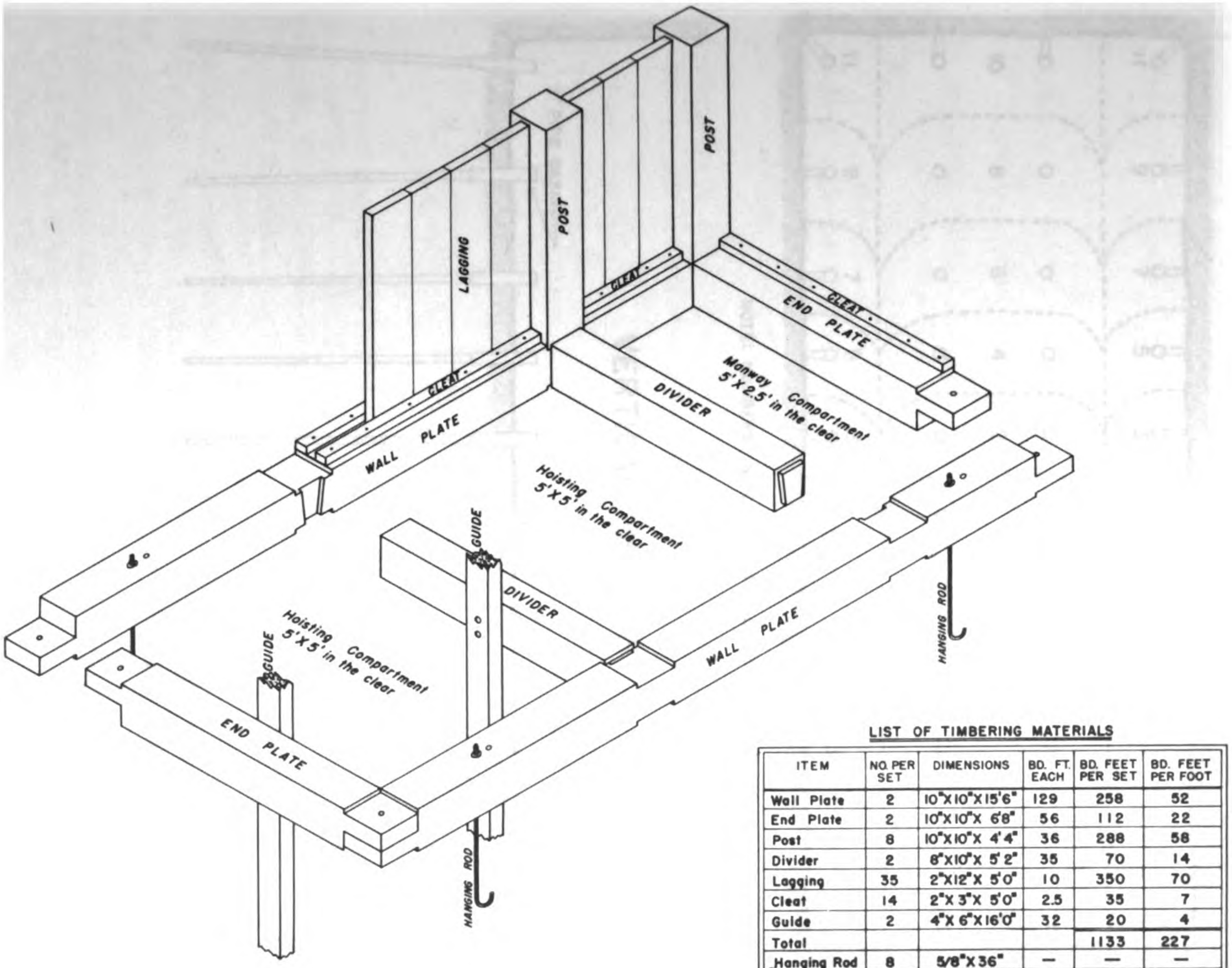
SHAFT SINKING

Actual shaft sinking was begun in February 1945 and completed in July 1946. During this period, 750 feet of shaft was completed below the main drift and three sumps, each 50 feet long, were excavated at various levels. Including the 90-foot raise driven from the main drift prior to shaft sinking, the total depth of the Hope shaft is now 840 feet.

The excavated rock section averaged 17 by 7 feet. The ground did not overbreak. The shaft timbers were framed to provide two hoisting compartments, 5 by 5 feet in the clear, and one manway compartment 5 by 2.5 feet in the clear. Only one hoisting compartment was used while sinking. The manway compartment contains a 1-inch water line, 2-inch air line, 4-inch pump discharge line, and 10-inch vent pipe.

The following table gives details and dimensions of the shaft timbering:

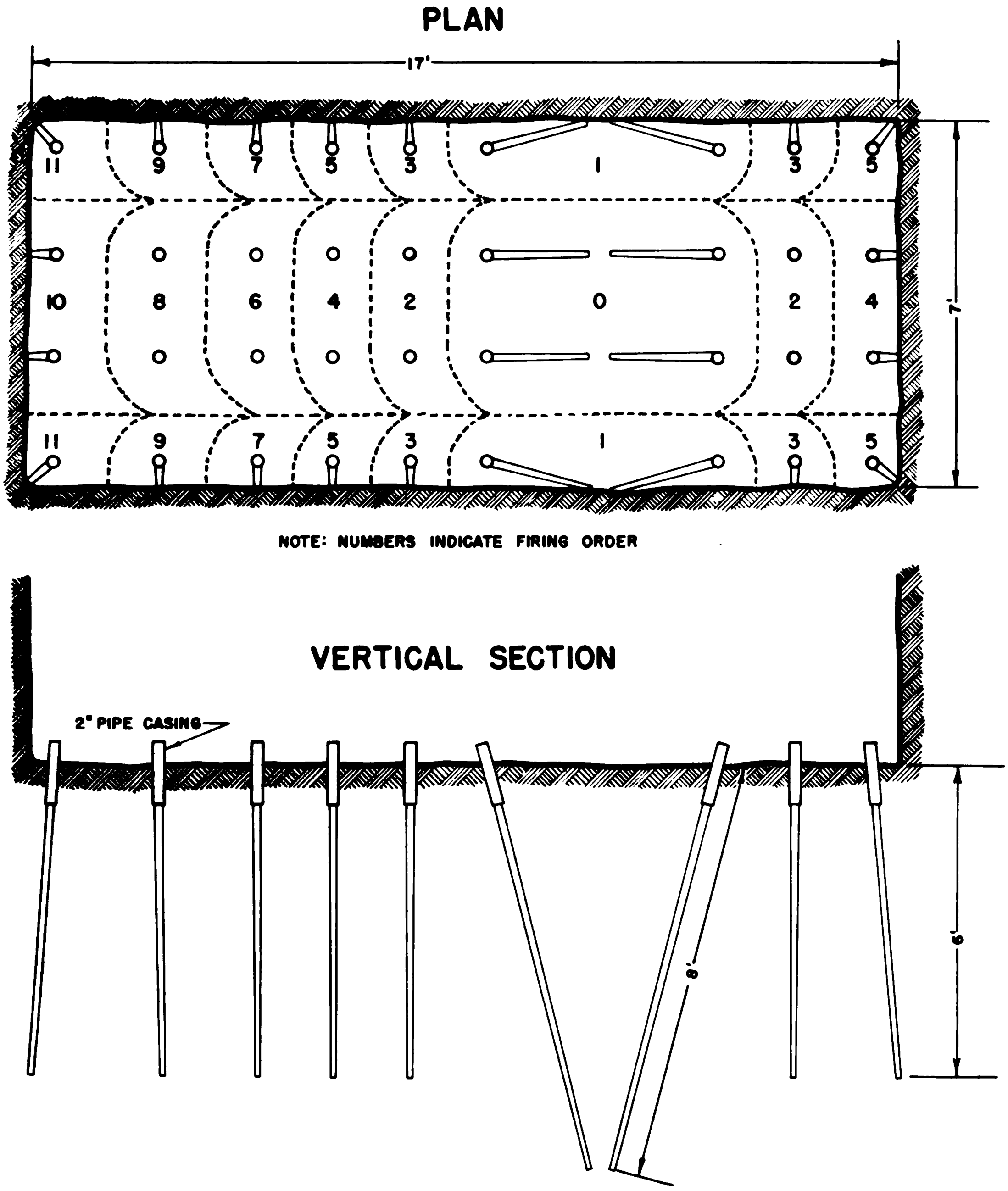
Original from THE OHIO STATE UNIVERSITY



LIST OF TIMBERING MATERIALS

ITEM	NO. PER SET	DIMENSIONS	BD. FT. EACH	BD. FEET PER SET	BD. FEET PER FOOT
Wall Plate	2	10"X10"X15'6"	129	258	52
End Plate	2	10"X10"X 6'8"	56	112	22
Post	8	10"X10"X 4'4"	36	288	58
Divider	2	8"X10"X 5'2"	35	70	14
Lagging	35	2"X12"X 5'0"	10	350	70
Cleat	14	2"X 3"X 5'0"	2.5	35	7
Guide	2	4"X 6"X16'0"	32	20	4
Total				1133	227
Hanging Rod	8	5/8"X36"	—	—	—
Lag Screw	4	5/8"X8"	—	—	—

Figure 3. - Details of Hope shaft timbering.


PLAN

NOTE: NUMBERS INDICATE FIRING ORDER

VERTICAL SECTION

Figure 4. - Details of the Hope shaft round.

List of timbering materials

Item	No. per set	Dimensions	Bd. ft. each	Bd. ft. per set	Bd. ft per foot
Wall plates ..	2	10" x 10" x 15'6"	129	258	52
End plates ...	2	10" x 10" x 6'8"	56	112	22
Posts	8	10" x 10" x 4'4"	36	288	58
Dividers	2	8" x 10" x 5'2"	35	70	14
Lagging	35	2" x 12" x 5'0"	10	350	70
Cleats	14	2" x 3" x 5'0"	2.5	35	7
Guides	2	4" x 6" x 16'0"	32	20	4
Total				1133	227
Hanging rods..	8	5/8" x 36"	-	-	-
Lag screws ...	4	5/8" x 8"	-	-	-

The framing, which is more or less standard for shaft sets, is shown in figure 3. Timbering was done as soon as possible after blasting and before mucking started. This cycle was necessary to provide time for pumping out the water accumulated while the pumps were idle during the blasting period. The Coeur d'Alene method of lagging between the timbers by means of cleats was used. Approximately 20 shaft sets, or 100 feet of timbering, were lagged at a time. Two men lagged and cleated five sets in 8 hours.

Bearing sets were installed at intervals of 100 feet. The bearing sets are 10- by 10-inch timbers hitched in each wall of the shaft in such a position as to directly underlie and support the two end plates. Short posts are then used under the bearing timbers at the four corners. To prevent the posts from being squeezed inward, a 2-inch lagging, 5 feet long, was spiked to the bottom of each bearing timber between the posts.

CYCLE OF OPERATIONS

Drilling

Figure 4 shows the standard shaft round adopted. This was proved to be the most efficient round for breaking the ground. Many other types of rounds and methods of blasting were tried, tested, and discarded in the early experimental stages.

The shaft round consisted of 36 holes, arranged in a pattern consisting of 9 rows of 4 holes each. The holes were all 6 feet deep, except for the cut holes, which were 8 feet. An average round pulled 5 feet.

All the holes were started with an Ingersoll-Rand, JA-55 jackhammer using a 2-3/8-inch-gage starter bit. The holes were drilled to a depth of 6 to 12 inches with this machine; and then a short piece of 2-inch casing, 10 to 16 inches long, was inserted in the hole to keep out the dirt and water. The next steel used had a bit gage of 1-7/8 inches. The remainder of each hole was drilled with a hand-held DA-30 Ingersoll-Rand combination sinker and drifter drill. One jackhammer was used for starting the holes, but two sinkers were used for drilling the round.

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Standard, 1-inch, hexagonal, hollow drill steel with conventional, forged crossbit was used. Two foot changes of drill steel were used with bit gages and lengths as follows:

Changes	Drilled length	Gage, inches	Drill used
Starters	0 to 6" 12"	2-3/8	JA 55 jackhammer
2ds	6"-12" to 2 feet	1-7/8	DA-30 sinker
3ds	2' to 4'	1-3/4	Do.
4ths	4' to 6'	1-5/8	Do.
5ths	6' to 8'	1-1/2	Do.

The over-all average time for drilling a round was 20 man-hours. About 230 feet of hole were drilled per round. An average of 50 pieces of drill steel was necessary to complete each round. Wear and tear of drill steel were not excessive.

Water was used for drilling. The water manifold had two connections for the water hose. Air pressure at the machines was about 90 pounds. The air manifold had connections for two machine hoses, one pump hose, and one blow pipe . Three line oilers were used, two for the machines and one for the pump.

Blasting

Several kinds of powder were tested before it was satisfactorily demonstrated that 40-percent special gelatin dynamite gave the best results. Twelve to fourteen delay speeds of Atlas electric detonator caps were used in blasting the V-type cut round. Cap insulators were employed to keep out the water and help prevent misfires. Each hole was cased with 10- to 16-inch lengths of 2-inch pipe. These casings were blasted with the round because it took too much time to pull them. About 50 percent were recovered.

Eight sticks of powder were used in each square-up hole and 10 sticks in each cut hole. The primer was the second cartridge loaded in the hole. Little difficulty was experienced with misfires, notwithstanding the fact that the water made blasting conditions far from ideal. Three rounds were lost because of poor caps.

The 12-foot waterproof leads of the No. 6 electric caps were wired in a parallel-series system. The four holes across the short dimension of the shaft were wired in series (nine series in all). The series were wired in parallel between two bare wires strung on wooden stakes, 3 feet high, along each side of the shaft.

The permanent blasting circuit in the shaft carried 110 volts over rubber-covered, heavy copper leads (No. 10 wire). A conventional blasting switch was in the portal of the adit. It was kept locked at all times, except when the rounds were blasted by the jigger boss. A No. 20-gage wire connected the permanent circuit to the two bare wires stretched across each side of the shaft.

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Approximately 2½ man-hours were required for loading and blasting a round. After the round was blasted, 1 hour was required to blow out the powder gases. For this purpose, a 10-horsepower electric blower fan was installed at the portal of the drift. The fresh air was blown through a 10-inch vent line supported in the manway compartment of the shaft.

A 2-ton blasting set, or steel "battleship", protected the shaft timbers during blasting. The "battleship" was made of ½- by 10-inch steel plates conforming in plan to the exact size of the shaft timbers; it was reinforced with a 3-inch angle iron welded along the bottom. The blasting set was held tightly against the bottom shaft set by four bolts passing through the hanging rod holes.

The blasting set was used also to support a suspended staging when timbering was done. When used for this it was decked with lagging and suspended 6 feet below the last set by six cables, each 13 feet long. These cables were hooked around the end plates and wall plates of the second-lowest shaft set.

Two separate cable slings were used for lowering the blasting set. One of these slings could be attached to the bottom of the bucket on the main hoist; the other to a cable from a single drum air tugger hoist in the manway compartment about 50 to 100 feet above the bottom of the shaft. The blasting set was lowered until the six hooked cables assumed the full suspended weight of the blasting set at the correct distance below the last set, that is, 6 feet. The two slings were then removed, leaving the hoists free to be used for lowering timbers and for assisting with the timbering operation.

Timbering

The sinking pump was pulled before each blast. During the 1 hour allowed for clearing gases, the water would rise to 3 or more feet above the muck pile. Thus it was necessary to timber immediately after blasting. During this time the pump removed the water.

The bottom of the shaft was never less than 20 feet below the timber. After the staging had been lowered and arranged as explained above, the following operations ensued: The two wall plates were hung on the 5/8-inch hanging rods, end plates were then doweled into position, the dividers were dropped into place, posts set upright, the hanging rods tightened, and the set securely blocked into correct alinement whith 10- by 10-inch blocking and sawed wedges. Hand-made ratchet wrenches were used for tightening the hanging rods. Each ratchet was made from a discarded jackhammer chuck and a gear from an old air tugger.

Four plumb lines were used for plumbing and squaring the sets, one line at each corner. The lines were hung 1 inch from the timbers on each side. The plumb-line reels were moved from bearing set to bearing set at intervals of 100 feet. If necessary, the bearing sets were squared and leveled before the reels were moved. From a depth of 300 feet to the bottom of the shaft the timber never had to be releveled. This accuracy was attained by constant supervision of the framing and blocking of the timber sets.

The shaft was lined with 2-inch random-width fir lagging, 5 feet long, placed between 2- by 3-inch by 5-foot cleats nailed to the wall and end plates of each set. Generally, about 100 feet of shaft timber, or 20 sets, were lined at a time.

The time required to put in one set averaged 20 man-hours. This did not include 3-1/3 man-hours required for lining each set.

The timber is not treated. The shaft is so wet that the timber should, it is believed, withstand decay indefinitely or for the life of the mine.

Mucking

It was first planned to scrape up the broken rock with the hoisting bucket. For this reason, all hoisting was done in the end hoisting compartment. The idea was to blast the rock into a pile at the hoisting compartment end of the shaft where a large part of the rock could be loaded by dragging the empty bucket against the pile. This plan proved, however, to be impracticable because the thin-bedded rock tended to break into flat slabs which stood on end. As a result, all mucking was done by hand. The hand-mucking operations could have been better served if the hoisting had been done in the middle compartment.

Sinking buckets of 12-cubic-feet capacity were used. One bucket was loaded at the bottom while the other was being hoisted and dumped. It required about 9 minutes per average round trip to hoist, dump, and return the bucket. The buckets were coupled to the chains by patented Coeur d'Alene Hardware Co. hooks, which can be removed from the bail only when the cable is slacked. The buckets are suspended on two chains, 12 feet long, from a conventional sinking cross head equipped with 9-ton safety dogs. The safety dogs are standard saw-toothed eccentrics held away from the guides by a heavy spring suitably controlled and stressed by the tension in the hoisting cable.

An average of 50 man-hours was required to muck out a 5-foot round. Ninety-five to 110 buckets were mucked per round.

Pumping

Although no surface drainage entered the shaft, it soon became evident that there was a considerable flow of water in the fractures and bedding cracks of the formation. The pumping problem was small during the sinking of the first 100 feet. At this low head a No. 7 Chicago-Pneumatic sludge pump handled the small volume of water to good advantage. Below 100 feet it was necessary to use two Ingersoll-Rand No. 35, air-operated, sump pumps in series. These worked satisfactorily to a depth of 200 feet. At a depth of 235 feet, however, the system had to be modified. A sump was cut horizontally at a depth of 235 feet in the shaft. This consisted of a 50-foot drif to the east, bulkheaded in the usual manner with a concrete dam. This dam was only partly successful in holding back the water. Some water seeped around the bulkhead through the rock and flowed back down the shaft. An

Ingersoll-Rand Motorpump, operated by a 15-horsepower 440-volt electric motor was installed at the sump. This pumped the water directly to the surface. The two air-driven pumps at the bottom of the shaft pumped to the sump. At a depth of 410 feet, another sump had to be cut. A drift was, therefore, driven at this level 50 feet into the east wall of the shaft, and two full rounds were taken out of the bottom of the last 40 feet. This provided a 10-foot rock wall for a bulkhead. A MRVN Ingersoll-Rand Motorpump operated by a 40-horsepower 440-volt electric motor was installed at this second sump; it pumped directly to the surface.

An attempt was made to use the 15-horsepower Motorpump and an air-operated sump pump in series, but this was entirely unsuccessful. The surging, fluctuating discharge from the sump pump was not a proper feed for the Motorpump.

It became evident that a surge tank was necessary between the two pumps to equalize the load on the Motorpump. A tank, 7 feet high and 4 by 4½ feet in cross section, was then constructed of sheet iron, reinforced at the four corners with 2-inch pipe, and provided with a bail. The tank was placed in the unused hoisting compartment and was maintained at a height of 50 to 100 feet above the bottom of the shaft. The discharge from the air-driven pump entered the bottom of the tank through a suitable check valve. The Motorpump was installed directly beneath the tank. A B.& W. liquid-level controller automatically started and stopped the Motorpump according to the height of the water level in the tank.

A drift sump was finally cut on the 700 station level. This eliminated the use of the surge tank. The present pumping system is as follows:

An air-driven pump at the bottom of the shaft pumps to the 700-level sump. From there a 40-horsepower Motorpump lifts the water to the 410-level sump where another 40-horsepower Motorpump lifts the water to the surface. Approximately 10,000 gallons of water are pumped per hour.

Recently the operators purchased a 60-horsepower Pomona turbine-type, deep-well pump. This pump will be installed in the northwest compartment on the 700-foot level. It has a 55-foot shaft casing and an impeller bowl 16 feet long. It is rated to pump 200 gallons per minute against an 800-foot head. When this pump is placed in operation it will eliminate the necessity of having to operate a 100-horsepower compressor over the weekends for the sole purpose of operating the sump pump.

COST OF SINKING

The Hope shaft was sunk as an independent operation, separate from any associated mining work. The cost, therefore, was higher than it would otherwise have been. The costs shown in table 1 are direct sinking charges only. They do not include any large equipment items.

TABLE 1. - Direct shaft-sinking costs, dollars per foot sunk

	Labor and super-vision	Drill re-pairs, steel, air, and water lines	Power	Explo-sives	Timber	Other sup-lies	Total
Drilling and blasting	8.297	1.164	-	6.463	-	-	15.924
Timbering	8.298	.800	-	-	10.39	-	19.488
Mucking	20.743	.166	-	-	-	-	20.909
Miscellaneous under-ground	4.149	-	-	-	-	-	4.149
Hoisting	12.229	.133	-	-	-	-	12.362
Decking and rock dis-posal	13.559	-	-	-	-	-	13.559
Blacksmithing	8.034	-	-	-	-	-	8.034
Timber framing	4.093	-	-	-	-	-	4.093
Supervision	14.127	-	-	-	-	-	14.127
Office, taxes, insur-ance, hospital	9.197	-	-	-	-	-	9.197
Pumping	-	2.083	-	1/ .493	-	-	2.576
Ventilation	-	.120	-	-	-	-	.120
Miscellaneous	-	.461	8.055	-	-	3.985	12.501
Total	102.726	4.927	8.055	6.956	10.39	3.985	137.039

1/ Cost of powder for cutting sumps.

The wage scale was as follows:

Classification	Rate per hour
Foreman	$1.12
Shaft-miner	1.02
Mucker	1.02
Blacksmith-mechanic	1.00
Hoistman	.92
Topman	.92
Timber-framer	.92

The men worked 6 days a week, except when occasional emergencies required work on the seventh day. Time and one-half was paid for all hours worked over 40 hours a week. The miners were paid either their regular wage, or at the rate of $35.00 per foot of shaft sunk, whichever was larger. The bonus thus paid ranged from 27- to 42 cents per hour higher than wages. The shaftmen bought their rubber work clothes at cost from the company.

The costs in units of labor, powder, and supplies are given in table 2.

TABLE 2. - Costs in units of labor, powder, and supplies
(April, May, June, July, 1946 - 224 feet sunk)

	Man-hours per foot
Underground Labor	
Drilling and blasting	6.346
Timbering	6.346
Mucking	15.866
Miscellaneous	3.173
Total shaft crew	31.731
Foot per 8-hour man-shift, shaft crew only	.2521
Surface crew	
Hoistmen	10.161
Dumping and disposing of rock	14.955
Blacksmithing, steel sharpening, repairs, electrical work	7.388
Timber framing	3.543
Supervision and office	11.665
Total surface crew	47.712
Foot per 8-hour man-shift, surface	.1677
Total crew - shaft and surface	
Man-hours per foot	79.443
Foot per 8-hour man-shift	.1007
	Per foot of shaft
Materials and supplies	
Explosives, 40 percent Spec. Gel.	34.197 pounds
Timber	Board feet
Shaft set (10- x 10-inch timber)	146
Blocking and lagging	92
Guides	4
Total	242
Drill steel	0.6 pound

TABLE 3. - Performance data

Time worked in shaft (750 feet sunk)	490 days
Average progress per 24-hour day	1.53 feet
Advance per round	4.72 feet
Number of rounds completed	159
Average rate of sinking per month	45.83 feet
Drilling	
Number of holes per round	36
Number of steels sharpened per round	50
Total drilling per round	232 feet
Drilling per foot of advance	49.15 feet
Average number of buckets hoisted per round	92
Average number of buckets hoisted per foot of advance	19.49